TES CO Data Validation and Application

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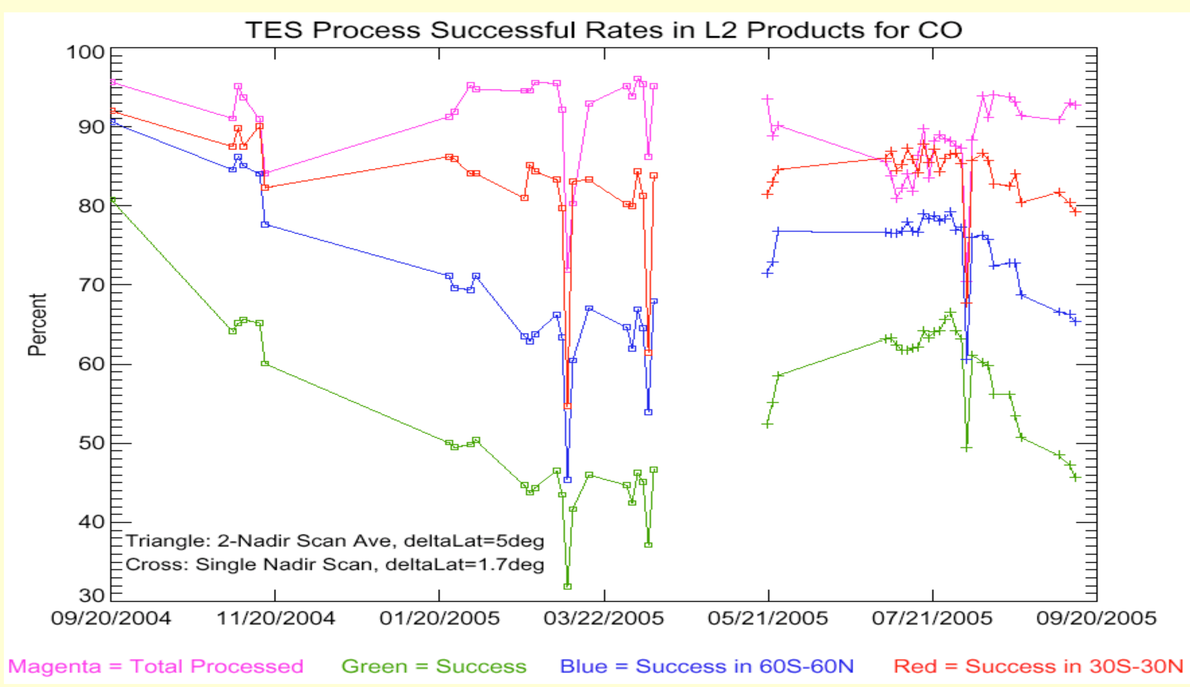
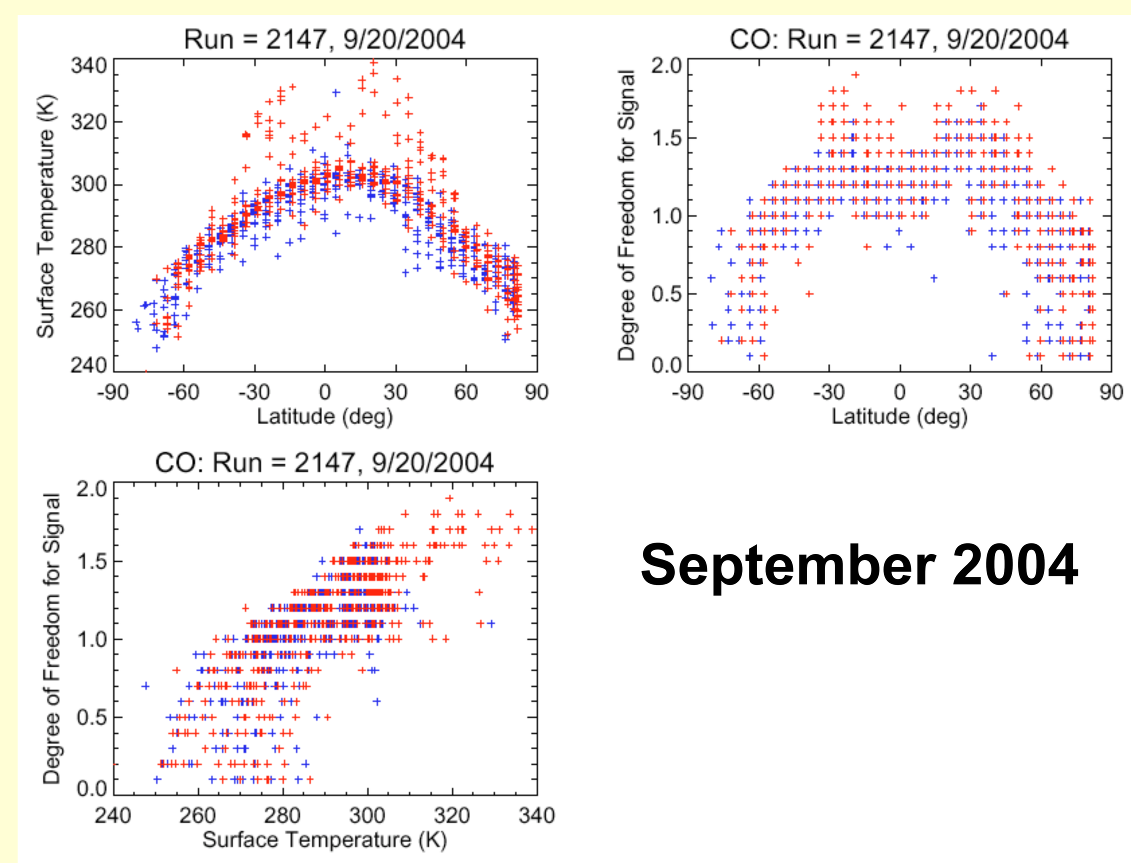
November – December 2005

1. TES instrument performance and CO retrievals

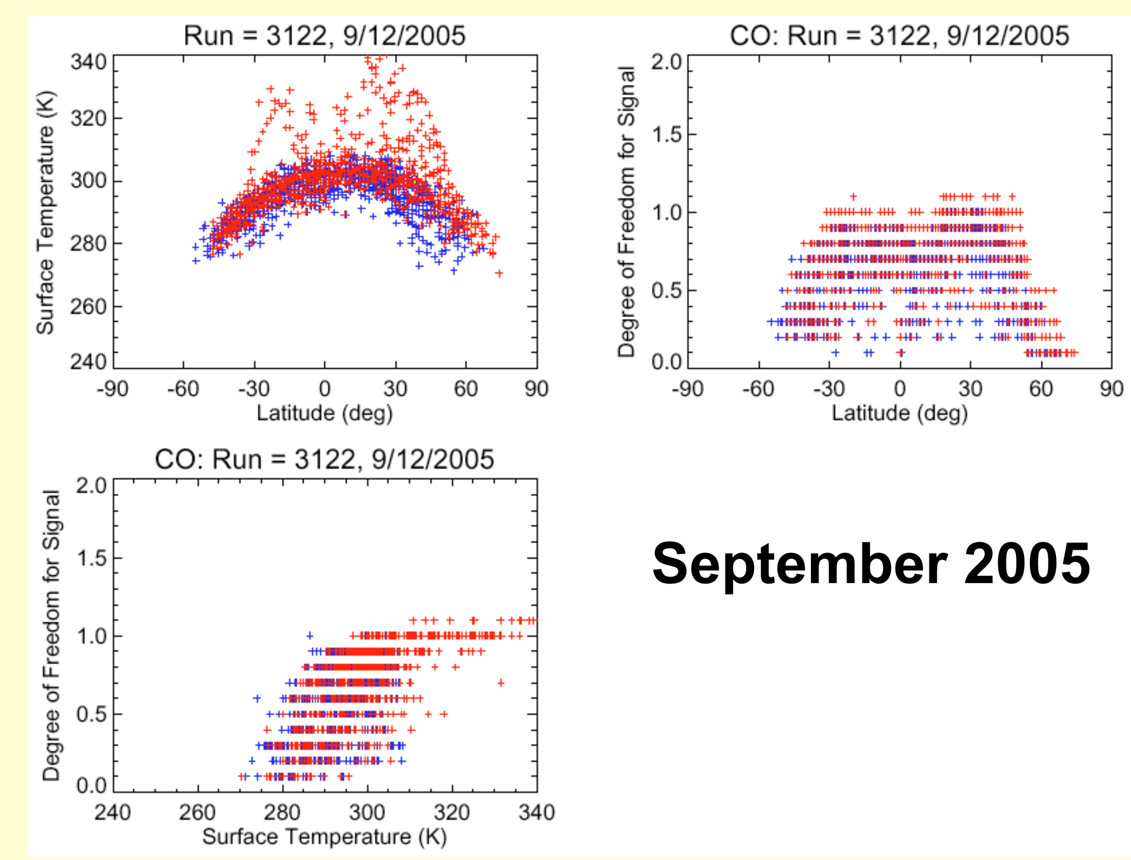


- **After the initial drifting, the optical alignment of the instrument has been stabilized. The signal strength of filter 1A1 used to retrieve CO, sensitive to the alignment, had declined and stabilized.**
- **The plot above shows the successful rate for TES CO retrievals per Global Survey as a function of time. The successful rate drops as alignment drifts, and it goes up during the northern summer months.**

Degrees of Freedom for Signals of TES CO retrievals and their relationship to surface temperatures – comparisons of data taken one year apart



September 2004



September 2005

2. The influences of a priori and instrument characteristics on retrieved CO products, on data inter-comparisons, and on data applications

Retrieved profile x_{ret} relates to the true profile x and a priori profile x_a as (*C. Rodgers,* Inverse Methods for Atmospheric Sounding, 2000)

$$x_{ret} = Ax + (I - A)x_a + \epsilon$$ **(retrieval error due to noise/systematic errors)**

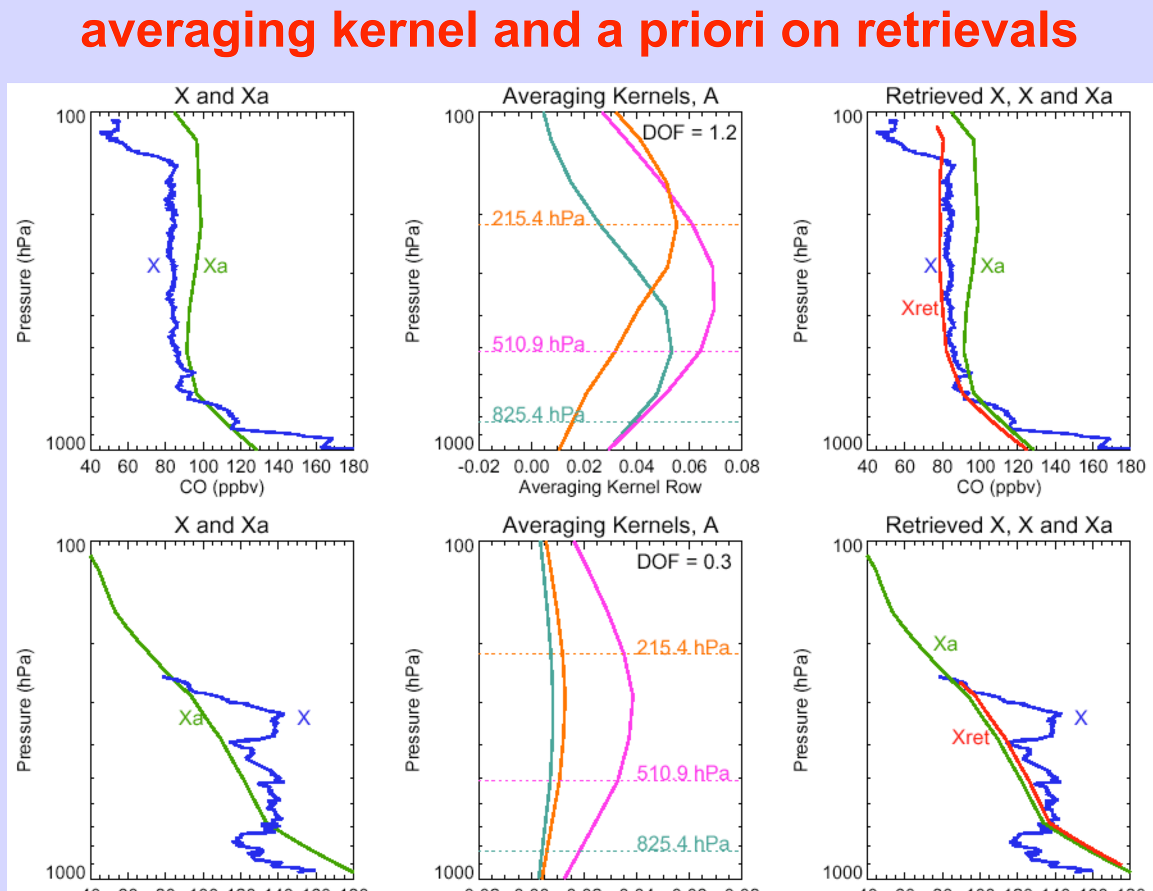
where *A* is the averaging kernel matrix.

- **The retrieved profile, x_{ret} and their derived columns are affected by the characteristics of the observing system.**
- **Without considering the differences in measurements and retrievals, the inter-comparisons of x_{ret} and the columns between two observing systems (instrument/retrieval algorithm) are not meaningful validations.**

Examples illustrating the roles of averaging kernel and a priori on retrievals

(1)

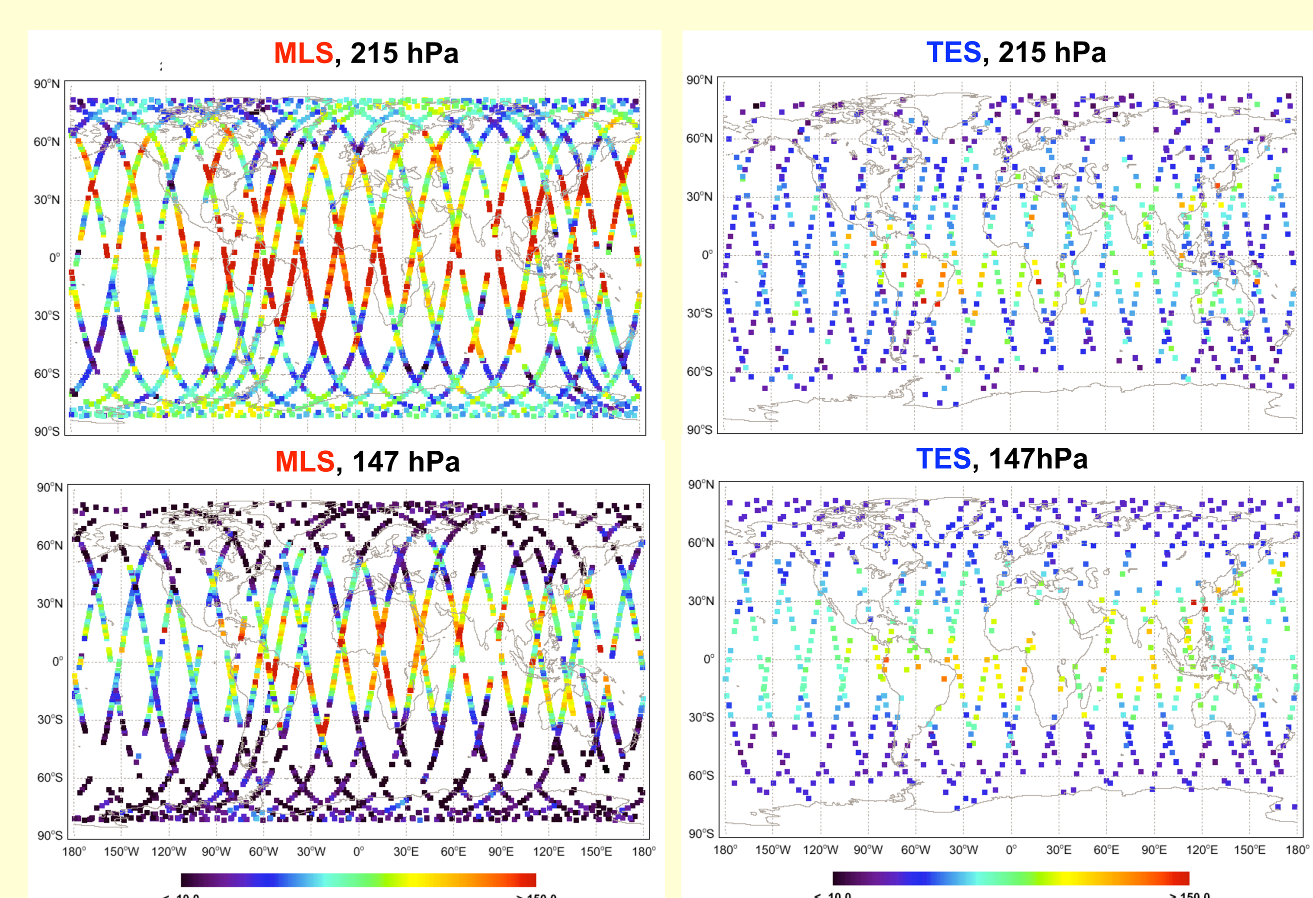
(2)



3. TES CO data validation status: comparisons to MLS and ACE

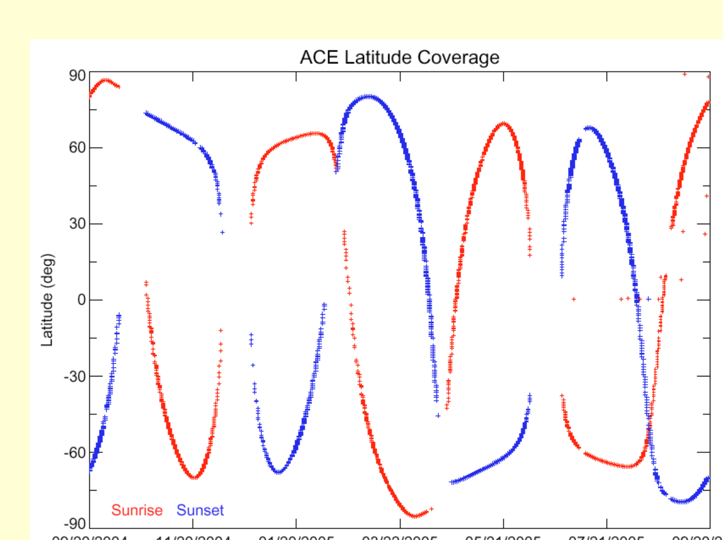
MLS and TES Comparison: Sept.20-21, 2004

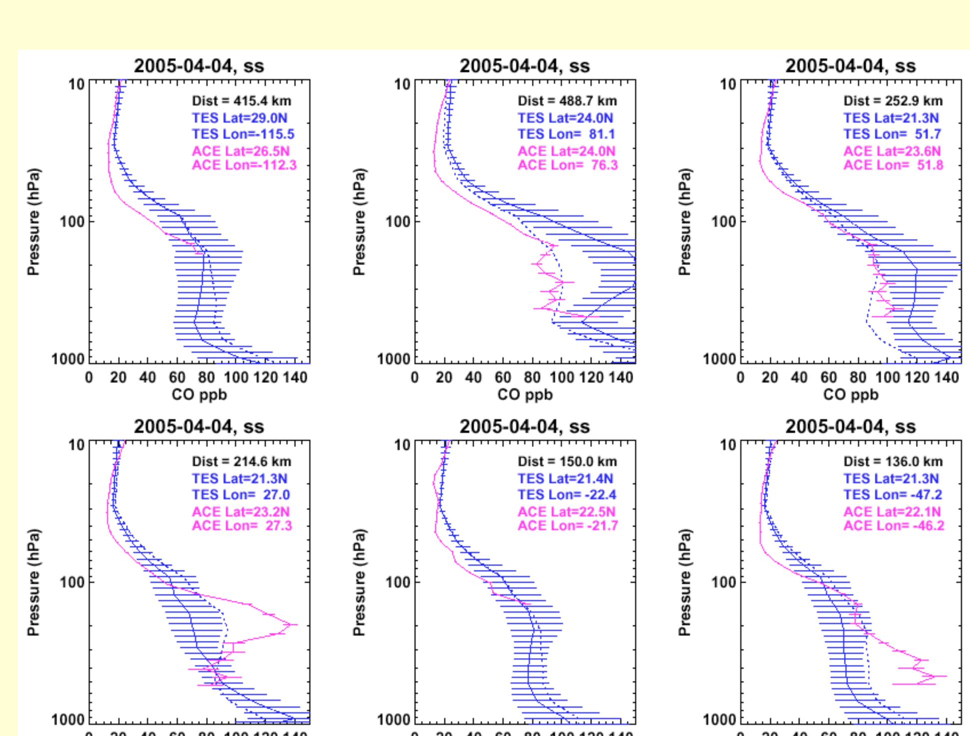
- **At 215 hPa, MLS CO VMR are higher than TES and models.**
- **At 147 hPa, MLS CO VMR are higher than TES in low latitudes and lower than TES in high latitudes.**

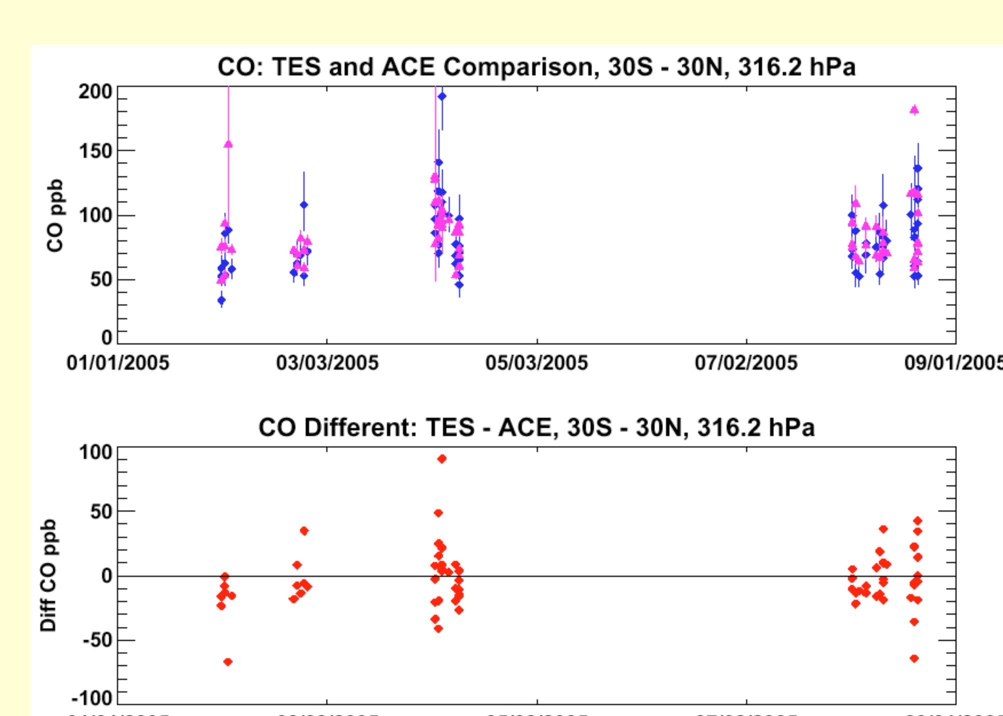


ACE and TES Comparison:

- **Match ACE and the available TES profile pairs for the following conditions: same day, 30S – 30N and 30N – 60N respectively, within 500 km.**
- **No systematic differences are seen in upper troposphere, *e.g.*, 316, 215, and 147 hPa.**







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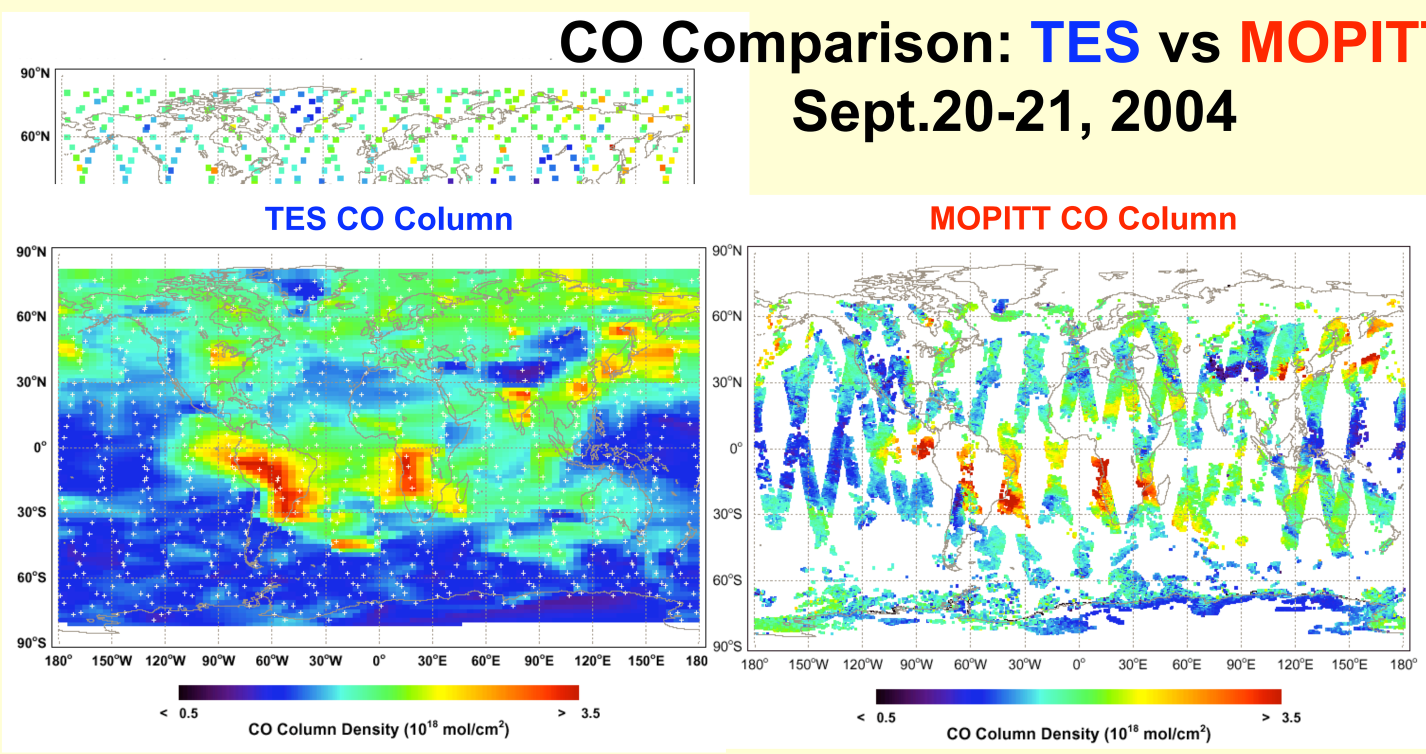
3. TES CO data validation status: comparisons to MOPITT and in-situ aircraft data (AVE & PAVE)

CO Comparison: TES vs MOPITT Sept.20-21, 2004



Figures to the Left:

- **TES CO retrievals at a footprint size of 5 x 8 km are mapped to Level 3 uniform lat/lon grids and images of CO at any given pressure level and total column are generated. The MOPITT instrument makes cross-track scans with a footprint size of 22 x 22 km. Similar size dots are used for illustrating its CO observations.**
- **After launch in 2004, The Degree-of-Freedom (DOF) for Signal for TES CO retrievals are about 0.5-1.5, up to about 2 in some regions and below 0.5 in some regions of high latitudes or cloudy scenes. MOPITT has similar vertical resolutions. In 2005, TES DOF dropped to < 1.2 due to the initial drift of instrument alignment.**
- **In a global scale, TES CO distribution agree well with that of MOPITT qualitatively. Both instrument observed elevated CO over and near the coast of S. America and Africa, and in east Asia, known to biomass burning and other pollution sources.**

Figures to the Right:

For Sept 20-21 2004 TES Global Survey time period, the MOPITT profile closest to every TES profile in distance within 500 km range is identified to make the comparison.

1) The TES and MOPITT CO VMRs at 850, 500, 150 hPa are compared as functions of latitude. The running averages for TES and MOPITT CO are also shown. The comparisons clearly illustrate the effect of a priori used in CO retrievals on the results. TES uses MOZART model while MOPITT use a single profile derived from aircraft measurements of CO as a priori, respectively.

2) The MOPITT CO adjusted to TES a priori (Rodgers & Connor, 2003),

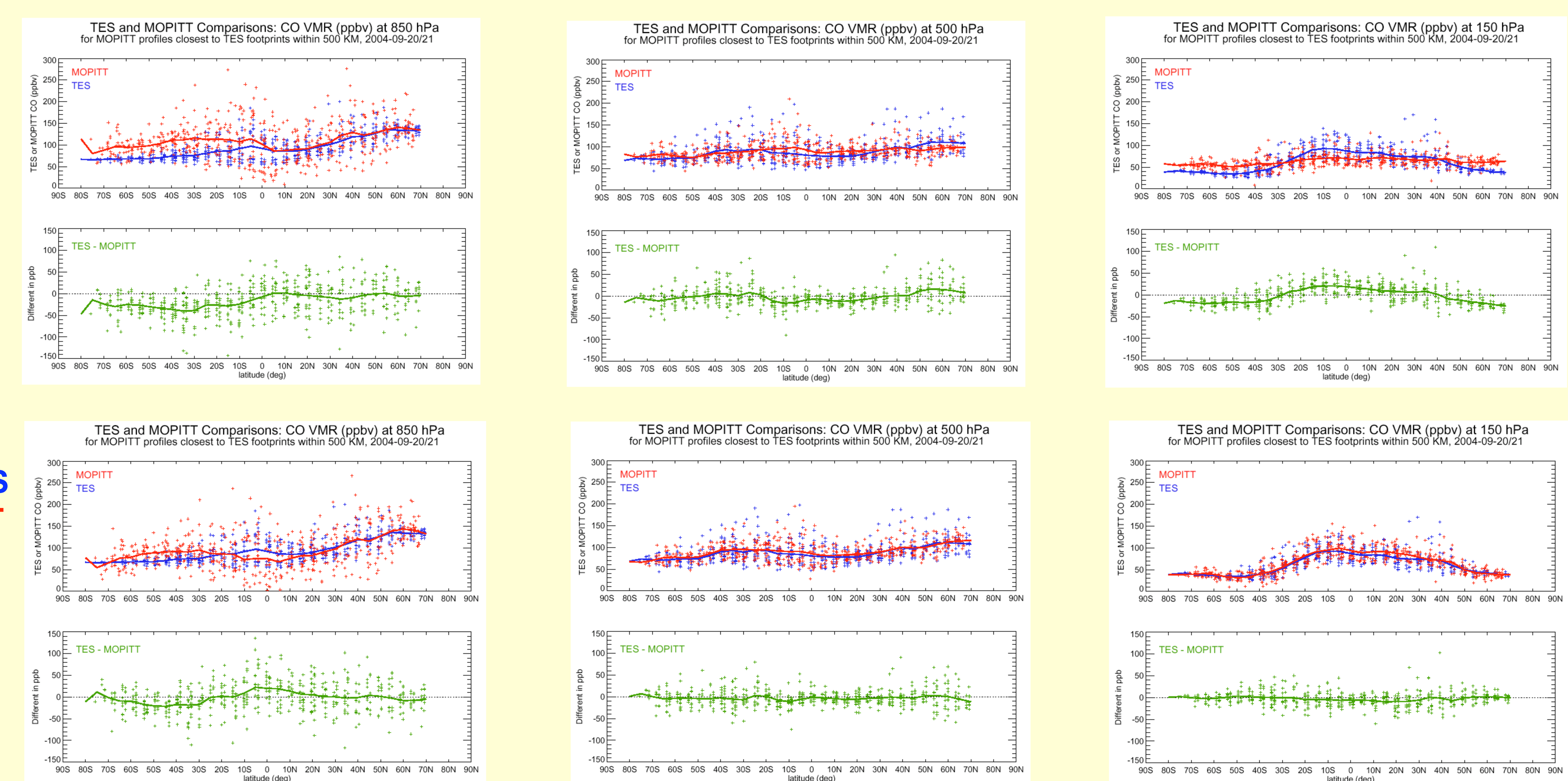
$$x_{ret}^{mopitt} - x_a^{tes} + (A^{mopitt} - I)(x_a^{mopitt} - x_a^{tes})$$

are compared to TES CO. Better agreements are achieved. Especially at levels that retrievals are not sensitive to measurements, *e.g.,* 150 hPa.

850 hPa | 500 hPa | 150 hPa

(1) Original TES and MOPITT

(2) Original TES and MOPITT adjusted to TES a priori

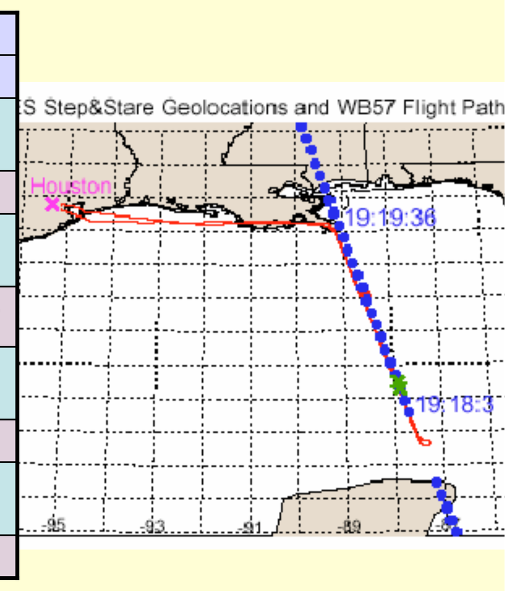


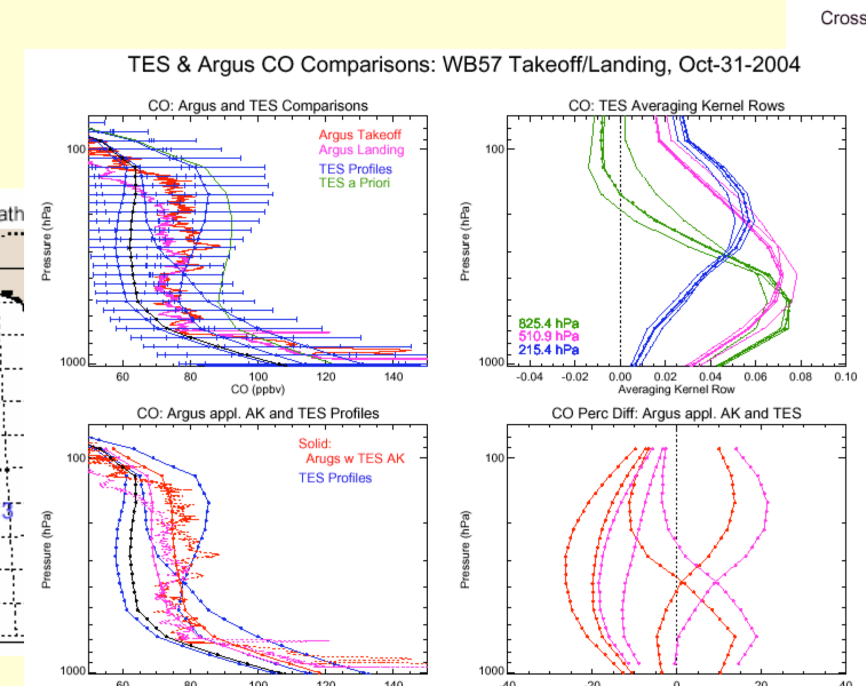
TES CO Validation with Aircraft in-situ Profiles (Argus in AVE and DACOM in PAVE)

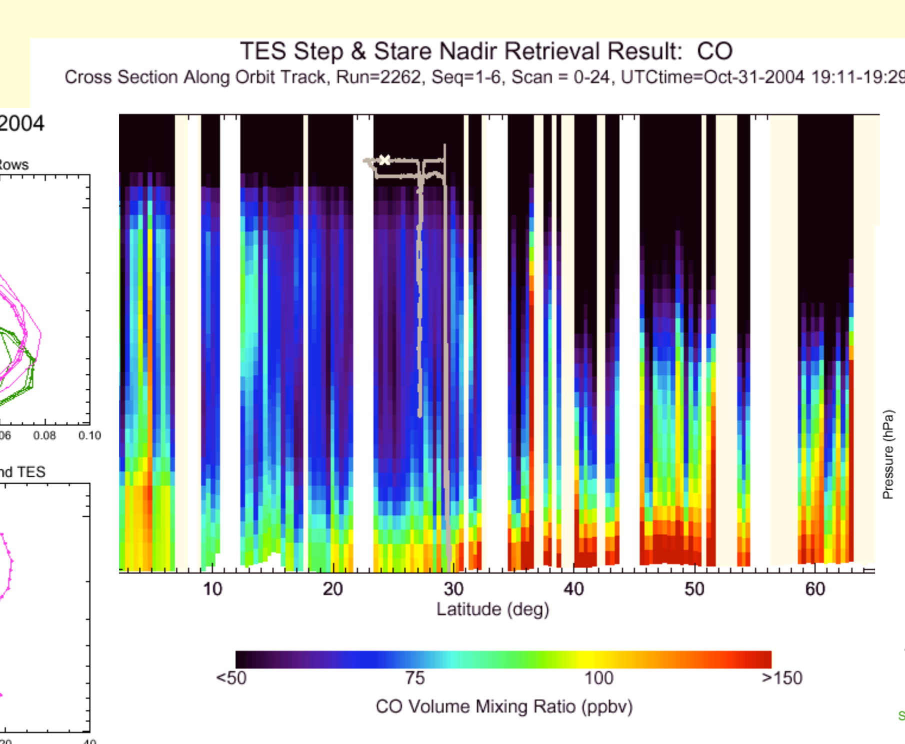
- Total of 18 Aircraft CO profiles. 4-6 TES profiles are selected to compare with each of them – total of 43 TES profiles.
- The Argus CO profiles are all extended upward and downward to the ground (for the diving profiles) using shifted TES a priori profile before applying TES averaging kernel and a priori profile.
- For comparison, the Argus CO profiles are converted to "TES nadir retrieval equivalent" profiles via applying TES averaging kernels and a priori profile: x = A(x_argus – x_a) + x_a.
- The differences between Argus and TES CO profiles are within TES retrieval errors and equivalent to CO spatial / temporal variabilities detected in both TES and Argus profiles.
- No obvious systematic biases are found in comparisons between Argus and TES CO measurements.

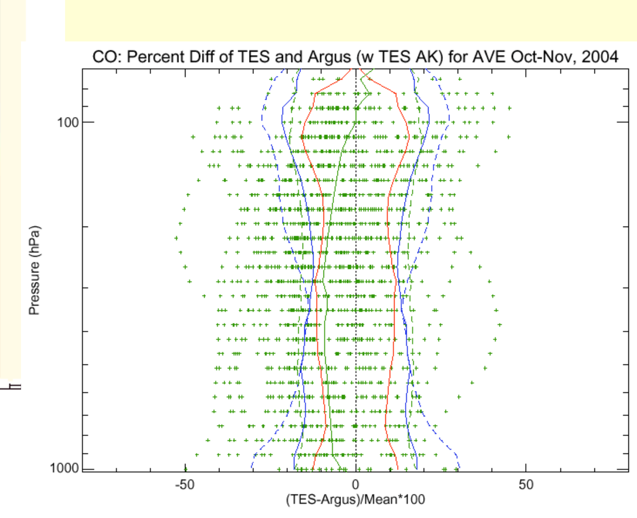
2004 Houston AVE

Date		Oct. 31	Nov. 3	Nov. 5	Nov. 7	Nov.9
TES Run		2262	2282	2290	2298	2305
Distance to Argus (km)	Takeoff /Landing	560-100	160-170	130-20	410-270	700-420
	Diving	10-15	130-150	60-150		20-200
Time From Argus (hours)	Takeoff /Landing	2.0 & 2.5	2.5&2.2	1.9 & 2.7	2 & 2.5	3 & 1.7
	Diving	0.5-1.5	0.4-1.0	0.4-1.3		(-1.0)-0.75
DOF	Takeoff /Landing	1.3	1.2-1.0	1.2	1.2	1.2-1.3
	Diving	1.3	1.2	1.2		1.1
Cloud OD	Takeoff /Landing	<0.1	<0.1 – 10.	<0.1	<0.1	<0.1
	Diving	<0.1	<0.1	<0.1		<0.6









4. Future TES CO validation plans and applications

- TES optical bench warm-up will improve the instrument alignment so to obtain better signal to noise ratio of the spectral measurement. As a result, TES CO retrievals will provide better vertical resolution (larger DOF) and precision.
- Sources for future validation comparisons
  - MOPITT: more dates, averaging kernel effect
  - AIRS: averaging kernel / a priori effects
  - MLS, ACE, MIPAS, SCIAMACHY
  - More AVE, INTEX, other aircraft in-situ, *e.g.,* NOAA/CMDL
  - MOZAIC. Ground based.
  - L1B spectra: filter 1A1 vs AIRS & S-HIS
- As a tracer for pollution sources and transport processes and as a precursor to troposphere ozone, CO plays an important role in tropospheric chemistry and climate studies. The remote sensing data offers optimally estimated CO distributions based on the measurements and some constrains, including the a priori knowledge. These products are influenced by the retrieval decisions made by the instrument team.

http://tes.jpl.nasa.gov

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